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US 4424865 A US 2723721 A
US 2305282 A

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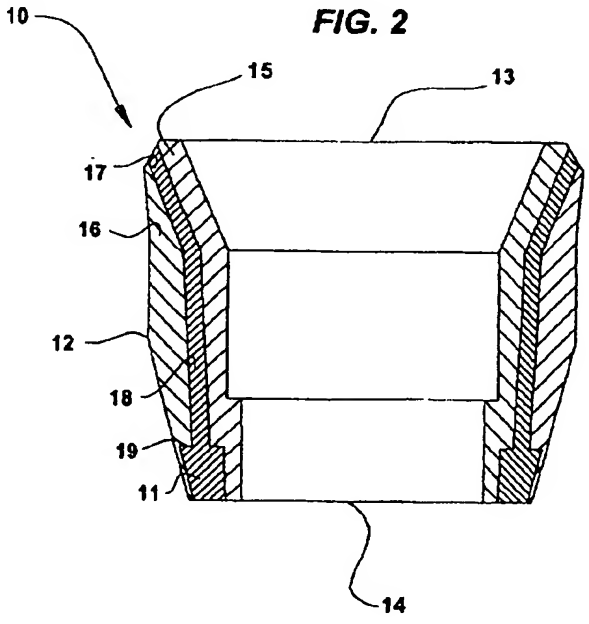
(54) Abstract Title
Packer cup

(57) A packer cup 10 for isolating a high pressure zone from a lower pressure zone comprises a base ring 11 from which an annular body 12 extends. An intermediate section 17 formed from interwoven high strength reinforcing plies 18, such as wires or cables, is attached to the base ring 11. The packer cup 10 comprises an inner and outer layer 15, 16 bonded onto either side of the intermediate section 17. The inner and outer layers 15, 16 are formed from an elastomeric or rubber material to form a unitary and flexible structure. The intermediate layer 17 acts as an continuous, but flexible reinforcement to allow the expansion and contraction of the packer cup 10. The intermediate section 17 further prevents the inner and outer elastomeric layers 15, 16 from extruding whilst under pressure.

FIG. 2



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

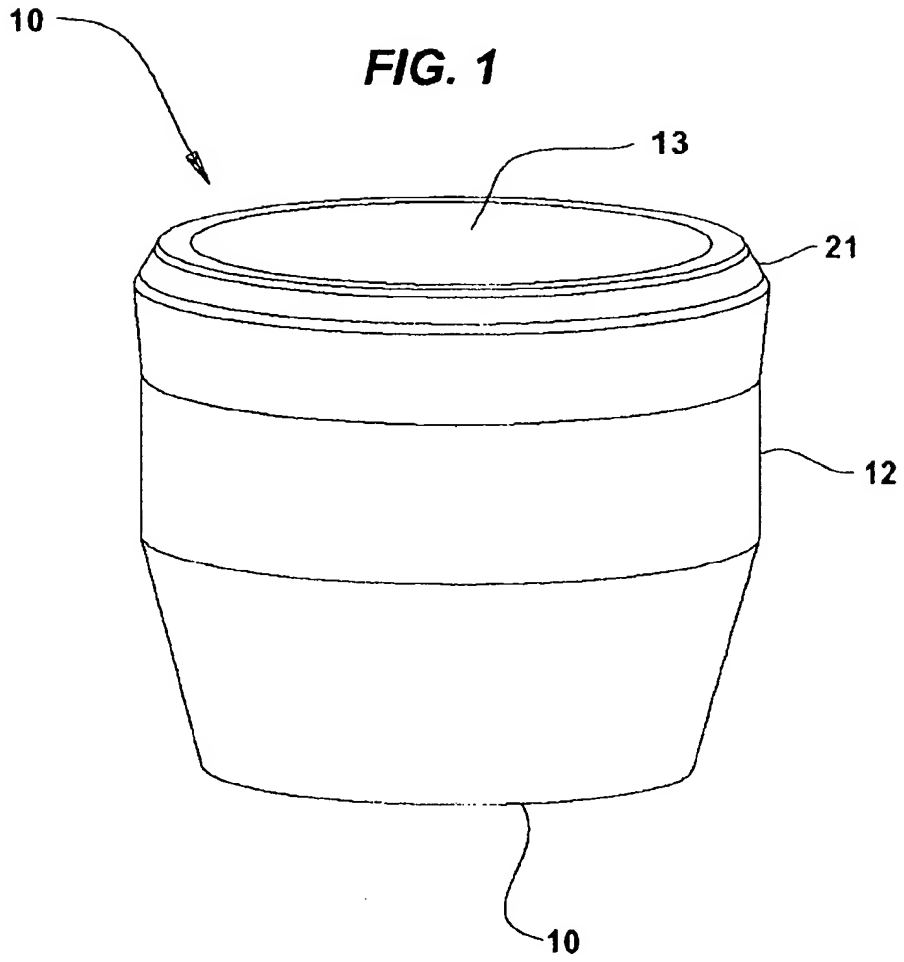
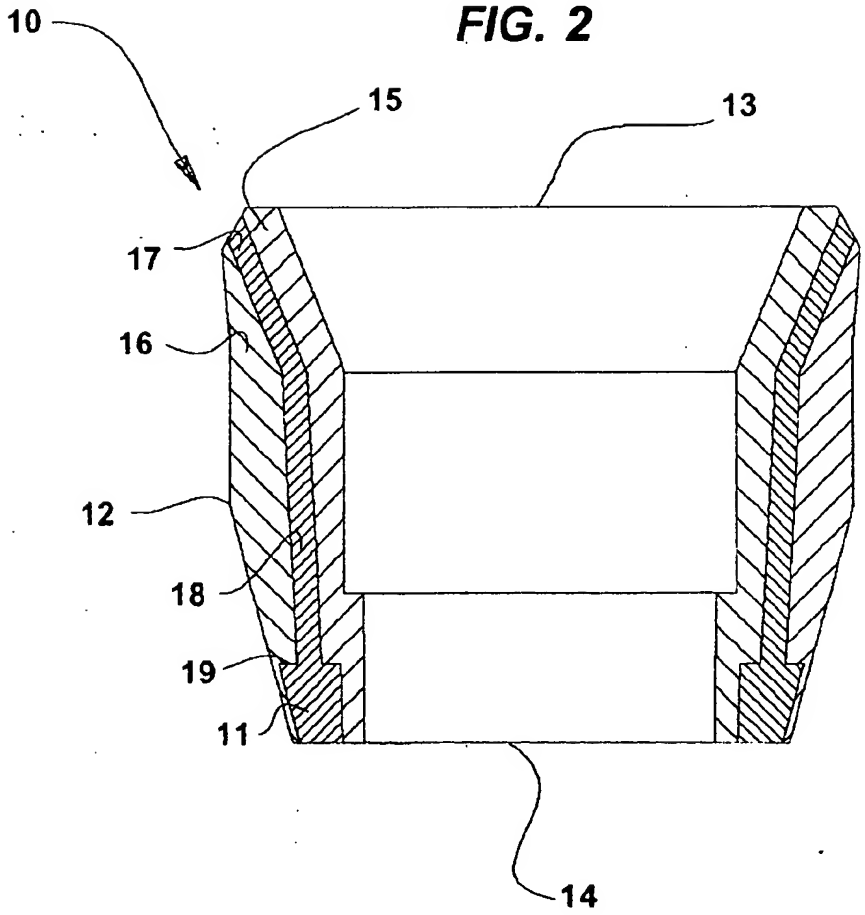


FIG. 1

FIG. 2



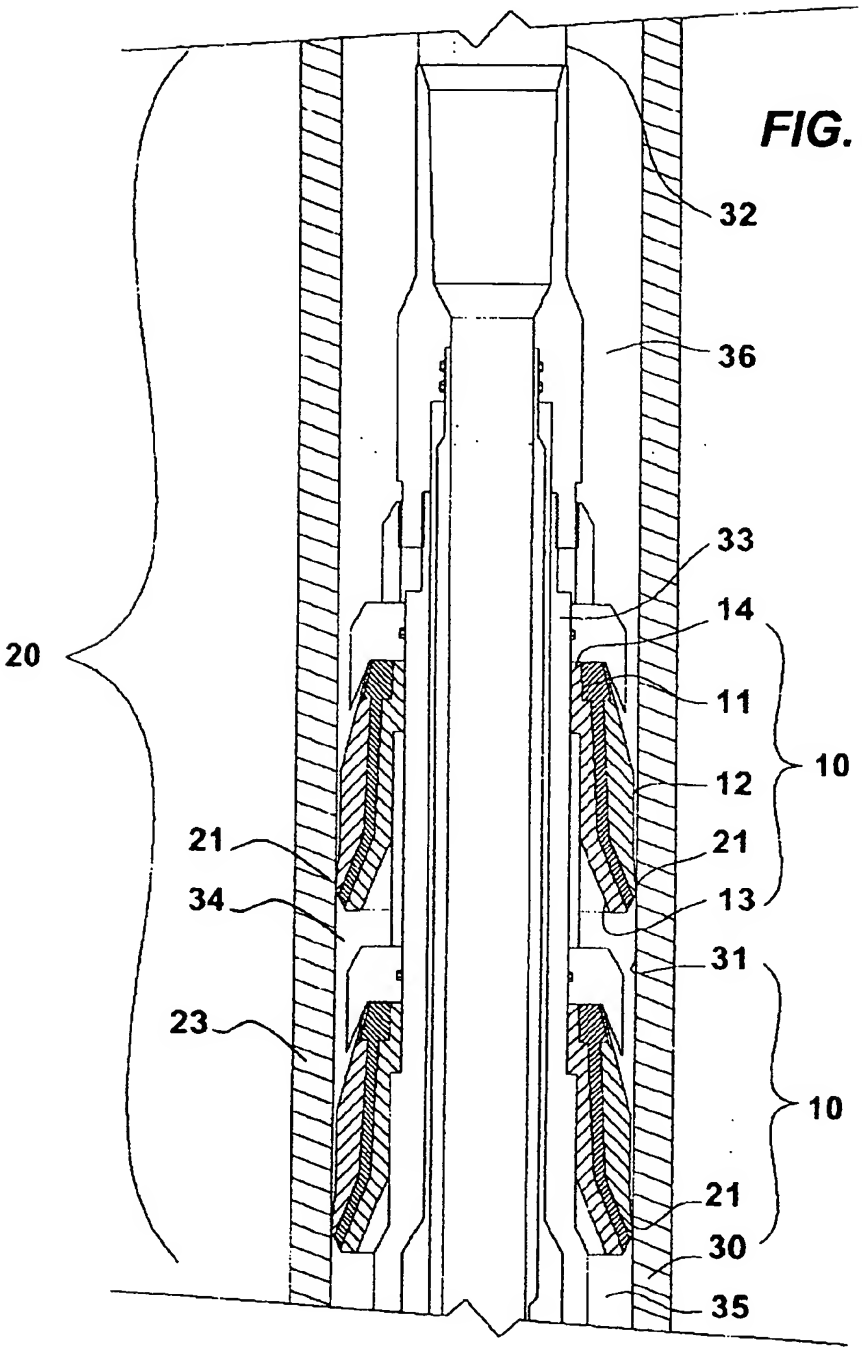


FIG. 3

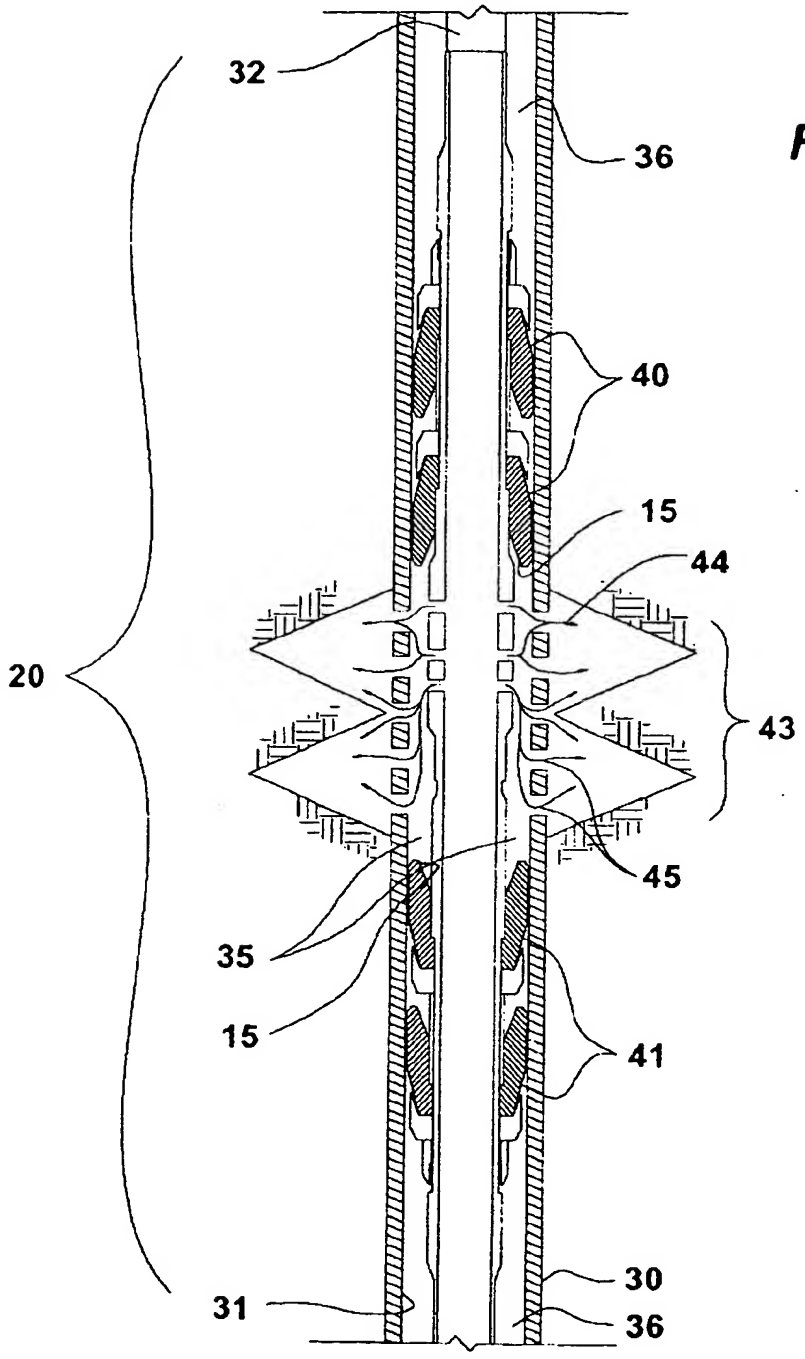


FIG. 4

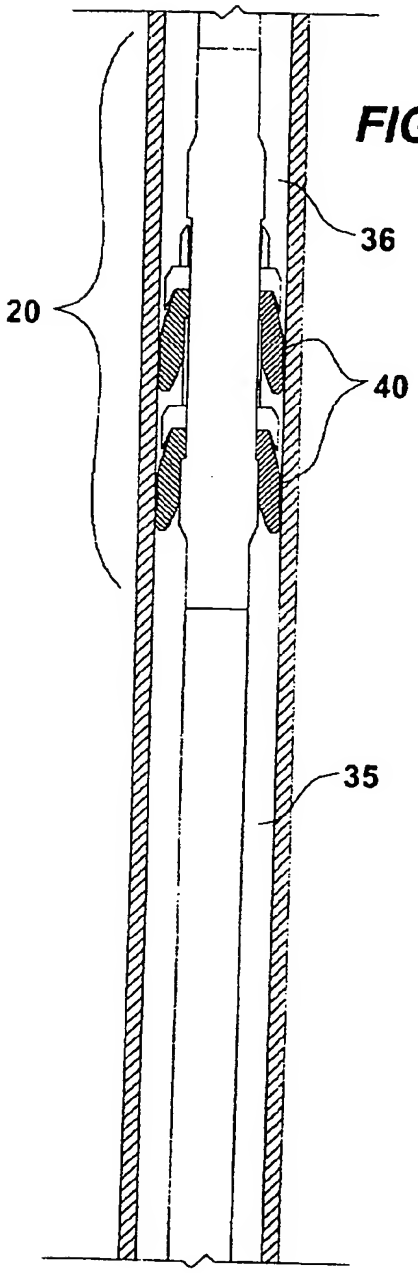


FIG. 5

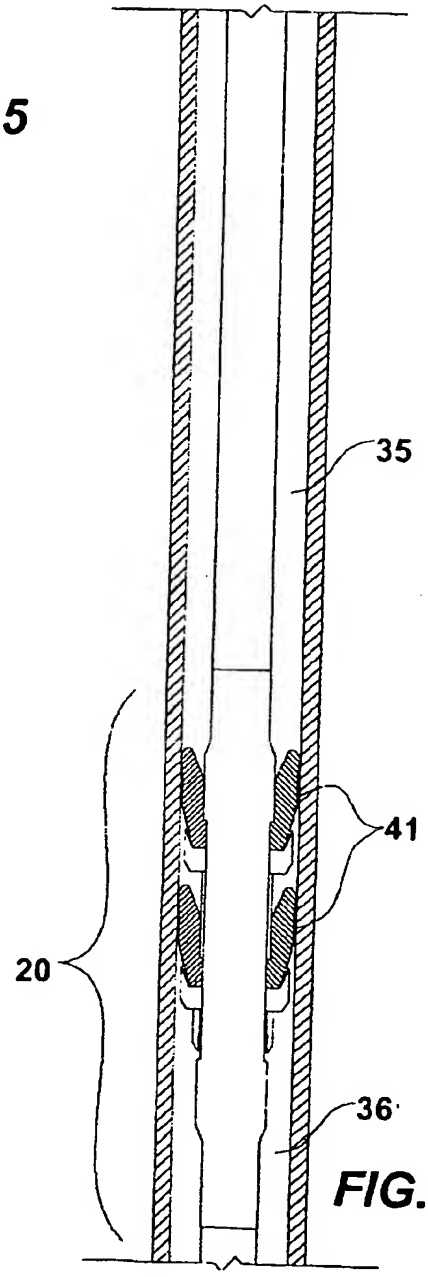


FIG. 6

"COMPOSITE PACKER CUP"

FIELD OF THE INVENTION

The present invention relates to packer cups and more specifically to packer cups used as seals in packer cup assemblies acting to isolate zones within a formation by sealing a portion of the wellbore.

BACKGROUND OF THE INVENTION

Packer cups are known for use in hook wall packers and other assemblies designed to isolate zones within a wellbore or to separate high and low pressure zones within a wellbore. Typically, this type of operation is performed for reservoir stimulations such as to stimulate a delimited portion of the well with the introduction of acidic solutions to enhance reservoir flow. Often the acidic solutions will further contain solvents, surfactants and anti-foaming agents all designed to aid in leaching substances, such as calcium carbonate and asphaltenes from the formation, resulting in the opening of pores to increase production. These constituents, dissolved in the highly acidic solution challenge the materials of construction of the assemblies, particularly the packer cups.

Historically, to access a zone in a wellbore, it was necessary to first "kill" the well by pumping a fluid into the well until sufficient hydrostatic pressure was obtained to overcome the pressure of the formation and prevent fluids from being blown out of the well. The wellhead was removed and the necessary treating apparatus tied into the production tubing. Following treatment the well was swabbed to re-instate production.

A number of assemblies have been designed to replace the historical process of killing the well, accessing and treating the well and swabbing to reinstate production. US Patent 3,380,304 to Cummins describes one of the earliest assemblies wherein a hollow high pressure mandrel, slidingly engaged within a high pressure casing was provided. The casing was adapted to seal against the wellhead and the mandrel adapted to seal to the top of the production tubing below the wellhead. Thus, the mandrel could be extended or retracted and fluids provided to the formation, all the while protecting the wellhead from high pressure. Seal means, between the outer surface of the mandrel and the interior of the production tubing, were required to pump sand-laden fracturing fluids out through the assembly described.

Mechanical packers and inflatable packers are known which can be positioned in a well and actuated to seal a zone in a wellbore. Other assemblies, such as hook wall, or cup-type packers are also known are inserted into the wellbore in their actuated state.

The cup-type packers are inexpensive compared to inflatable or mechanically actuated packers. The cup-type packers use elastomeric sealing cups fabricated from elastomeric materials having metal reinforcing fingers embedded in the elastomer. The cup is mounted on a pipe or mandrel for insertion into the well. To effect a downhole wellbore seal, the cups are generally oversized compared to the inner diameter of the well casing so as to bear against the casing wall. The contact of the seal, against the casing, is further enhanced by the resultant force of differential pressure across the seal. Typically, as described in US Patent 4,424,865 to Payton Jr., the reinforcing metal elements are fabricated as fingers which extend upwardly into the elastomeric body from a

metal base plate. The fingers expand radially outward, rotating from the metal base as a result of increases in temperature and pressure, forcing the cup into engagement with the casing side wall.

Conventional packer cups have a number of shortcomings. Firstly, as the cups are always "actuated" and in contact with the wellbore, the exterior of the cup is subjected to sustained mechanical abrasion against the casing side wall during insertion and removal from the wellbore. Typically, installation requires travel through a long bore which can result in removal of the exterior portion of the elastomer to the point where the seal is compromised.

Secondly, packer cups are fabricated from synthetic rubber materials that have limited mechanical properties under elevated temperature and that are susceptible to repeated exposure to aggressive wellbore fluids. Further, the interior of the packer cup is subjected to highly acidic, organo-solvent based wellbore fracturing fluids which are highly corrosive and also destructive to most synthetic rubbers, eventually resulting in a breach of the elastomeric material, often failing due to extrusion of the elastomer through in the spaces between the reinforcing elements.

Conventional packer cups are a compromise between chemical resistance, mechanical abrasion resistance and structural properties.

SUMMARY OF THE INVENTION

The packer cup of the present invention comprises, in a broad aspect, an inner chemically impervious elastomeric layer, an outer abrasion resistant elastomeric layer and an internal interwoven fiber-reinforced flexible layer, preferably metal. All three layers are formed into a unitary composite packer cup capable of withstanding repeated mechanical insertion and removal from the wellbore casing as well as exposure to harsh wellbore fluids. Further, the composite inner layer provides additional reinforcement throughout the entire cup structure, for strength to resist extrusion and withstand elevated pressures and temperature commonly found downhole.

Preferably the chemically impervious inner layer is Viton™ and the outer abrasion resistant layer is Nitrile™. The inner layer is an interwoven mesh of high strength fibers such as aircraft cable attached to an annular base ring. The cup has a body formed of the three layers which is shaped to flare upwardly and outwardly from the base ring and has an annular flange extending outwardly from the body adjacent an open first end for engaging the casing.

When the layers are bonded, preferably by vulcanizing, into a unitary structure, the cup can be used in a packer assembly for isolating a zone of high pressure containing harsh chemicals. The base ring is sealing engaged with a mandrel for threading into production tubing and the annular flange extends outwardly into an annulus formed between the production tubing and the casing for sealing engaging the casing. The open first end is oriented to face towards the zone of higher pressure so that the differential pressure across the cup can act to further seal the cup against the casing.

A plurality of cups may be used in each packer assembly, the cups being oriented to isolate the zone of interest. For isolating zones intermediate ends of the production tubing, the cups may be positioned uphole and downhole, with open ends facing or for other purposes such as isolating the wellhead from high pressure or cleaning perforations at the downhole end of a production string they may all be oriented uphole or downhole as the case may be.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a packer cup of the present invention;

Figure 2 is a cross-sectional view of a packer cup according to Fig. 1, showing the inner and outer elastomeric layers surrounding an intermediate interwoven, flexible fiber reinforcing layer;

Figure 3 is cross-sectional view of packer cups of the present invention installed in a packer assembly, the annular lip of the cup sealingly engaging the casing wall and the base ring sealingly engaging the tubing string;

Figure 4 is a schematic cross-sectional view of a packer assembly of Figure 3, having packer cups isolating a zone of high pressure intermediate the production tubing;

Figure 5 is a schematic cross-sectional view of a packer assembly having packer cups isolating a downhole zone of high pressure; and

Figure 6 is a schematic cross-sectional view of a packer assembly having packer cups isolating an uphole zone of high pressure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Having reference to Figs. 1 and 2, a packer cup 10 of the present invention is shown. The packer cup 10 comprises a base ring 11 from which an annular body 12 extends and which enables mounting of the cup to a tool or assembly 20 (Figs. 3-6). The cup body 12 has an open first end 13 having an annular lip 21 and which has a radial extent which is larger in diameter than the open second end 14. The second end 14 is attached to the base ring 11. Typically, the radial extent of the open first end 13 is slightly larger in diameter than an inner diameter of a wellbore casing string 30 into which the packer cup 10 is to be placed. As shown in Fig. 3, the smaller open second end 14 is sized to snugly fit the base ring 11, which is fit into a packer cup assembly 20 for insertion into a production tubing string 32.

As shown in Fig. 2, the packer cup 10 comprises three layers, an inner layer 15, an outer layer 16 and an intermediate layer 17, disposed therebetween. The three layers 15, 16, 17 are bonded together, such as by vulcanizing, to form the unitary packer cup body 12.

In a preferred embodiment of the invention, the inner and outer layers 15,16 are fabricated from elastomers which are specifically selected for the contrary environments.

The inner layer 15 is an elastomer. There are many elastomers which may be selected for chemical and temperature resistance.. Viton™ is such a chemically impervious synthetic elastomer. Viton™ is typically impervious to the corrosive nature of the wellbore fluids used in stimulation and fracturing. However, by comparison to other elastomers, Viton™ is relatively mechanically weak and not particularly resistant to abrasion.

The outer layer 16 is fabricated from a mechanically strong and tough elastomer. There are many elastomers which may be selected to toughness and temperature resistance. Once such elastomer is a synthetic such as Nitrile™. Nitrile™, which is relatively impervious to hydrocarbons and very mechanically strong such as for resisting abrasion. Nitrile™ does not have the chemical resistant properties of Viton™.

As shown in Fig. 2, the intermediate layer 17 comprises a mesh of biased or helical, interwoven high strength reinforcing plies 18, such as wire or more preferably aircraft cable, attached at a lower end 19 to the base ring 11. The mesh 18, is typically a helically wound assembly so that the cup's annular body can flex radially and expand and contract slightly with the inner and outer 15, 16 elastomeric layers. The plies 18 provide a substantially continuous structural reinforcement throughout a substantial portion of the body 12 of the packer cup 10. Examples of the manufacture and use of such mesh is known to persons in the art of inflatable packers. It is known to vary the thickness and number of cables, and helical build angle to affect their flexibility. Opposing helical winds of cable plies result in a criss-cross pattern which assists in avoiding extrusion of the inner layer 15 therethrough. An example of the selection of some of these parameters is set forth in inflatable packer US Patent 5,778,982 the entirety of which is incorporated herein.

In a preferred method of fabrication, the intermediate layer 17 is first attached to the base ring 11 such as by brazing and then is embedded within the inner 15 and outer layers 16. The packer cup 10, so assembled, is then vulcanized to bond the layers 15,16,17 into a unitary structure, capable of

withstanding differential wellbore pressures across the cup, which can in the range of 15,000 psi or greater without suffering extrusion failure.

Having reference again to Figs. 2 and 3, the cup's body 12 has an annular lip 21 formed adjacent the first open end 13 for engaging the inner wall 31 of the casing string 30. Further, the body 12 is tapered at the second end 14, about the annular ring 11 to allow insertion into the packer assembly 20.

As shown in Figs. 3 - 6, packer cups 10 are mounted to packer assemblies 20 having a mandrel 33 for threading into or otherwise suitably connection to a production tubing string 32, which is lowered into the wellbore casing string 30. The annular ring 11 of the cup 10 is sealingly engaged against the mandrel 33 while the annular lip 21 protrudes radially outward therefrom into an annulus 34 formed between the mandrel 33 and the casing 30. The protruding lips 21 of the packer assemblies 20 are squeezed into the casing 30 mechanically, by an insertion and rotation of the production tubing 32. Once in position, the annular lips 21 seal against the inner wall 31 of the casing string 30.

The cups 10 are preferably oriented having the first open end 13 directed toward a zone of higher pressure 35 and away from a zone of lower pressure 36 so that the differential pressure across the cup 10 further acts to drive the annular lip 21 of the cup 10 to seal against the inner wall 31 of the casing 30.

Fig. 4 illustrates one embodiment of a packer assembly 20 having uphole and downhole packer cups 40, 41 which act to isolate an intermediate zone of higher pressure 35 between the cups 40,41. This configuration of packer assembly 20 is typically used in high pressure acid stimulation of delimited portions of the formation 43 and is used to penetrate through a plurality of

wellbore casing perforations 45 to dissolve blockages and increase reservoir flow. In such an embodiment, the outer layer 16 of the cups 40,41 is subjected to abrasion during insertion while the inner layer 15 of each cup 40,41 is exposed to corrosive stimulation fluids 44.

Similarly, Figs 5 and 6 illustrate alternate and simple embodiments of assemblies employing the invention, each utilizing a single set of packer cups 10 in a packer assembly 20 for isolating a downhole or uphole zone of higher pressure, respectively.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEDGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An improved packer cup comprising:

an annular base ring for mounting to a packer assembly which is positioned in a wellbore casing to isolate a higher pressure zone from a lower pressure zone;

an annular cup extending from the annular base ring toward the higher pressure zone and having

an elastomeric inner layer, and

an elastomeric outer layer; and

an annularly extending flexible intermediate layer of reinforcing plies of material disposed between the inner and outer layers, and mounted at a lower end to the base ring, the inner, outer and intermediate layers being bonded together to form a unitary, flexible structure.

2. The improved packer cup as described in claim 1 wherein the inner elastomeric layer is fabricated from a chemically impervious elastomer.

3. The improved packer cup as described in claim 2 wherein the chemically impervious elastomer is Viton™.

4. The packer cup as described in claim 1 wherein the outer layer is fabricated from an abrasion resistant elastomer.

5. The packer cup as described in claim 4 wherein the abrasion resistant elastomer is Nitrile™.

6. The packer cup as described in claim 1 wherein the inner layer is fabricated from Viton™ and the outer layer is fabricated from Nitrile™.

7. The packer cup as described in claim 1 wherein the intermediate layer is formed of multiple, biased interwoven layers of reinforcing plies having upper and lower ends, the lower ends being fixed circumferentially to the annular base ring.

8. The packer cup as described in claim 7 wherein the reinforcing fibers are metal wire.

9. The packer cup as described in claim 7 wherein the reinforcing fibers are aircraft cable.

10. An improved packer cup for a packer assembly, the cup isolating a higher pressure zone from a lower pressure zone in the wellbore casing wherein an inside of the cup is exposed to corrosive chemicals and hydrocarbons and an outside to mechanical abrasion, the improvement comprising:

- an annular base ring;
- an annular cup extending from the base ring and toward the zone of higher pressure and having,

an elastomeric chemically impervious inner layer, and

an elastomeric abrasion resistant outer layer; and

an annularly extending flexible interwoven fiber intermediate layer, disposed between the inner and outer layers, and fixed at a lower end to the base ring, the inner, outer and intermediate layers being bonded together to form a unitary, flexible structure.

11. The packer cup as described in claim 10 wherein the inner layer is fabricated from Viton™.

12. The packer cup of claim 10 wherein the outer layer is fabricated from Nitrile™.

13. The packer cup as described in claim 10 wherein the inner layer is fabricated from Viton™ and the outer layer is fabricated from Nitrile™.

14. The packer cup as described in claim 10 wherein the reinforcing plies are metal cables.

15. The packer cup as described in claim 13 wherein the reinforcing plies are metal cables.

16. A cup-type packer assembly for positioning in a wellbore casing comprising:

a mandrel for positioning in the casing and forming an annulus therebetween; and

at least one packer cup, each cup having an annular base ring sealing engaged concentrically about the mandrel and an annular body for sealing against the wellbore casing for isolating a zone of higher pressure from a zone of lower pressure in the wellbore casing, the annular body comprising an elastomeric inner layer, an elastomeric outer layer; and an annularly extending flexible intermediate layer of interwoven reinforcing plies disposed between the inner and outer layers, the plies being mounted at a lower end to the base ring, the inner, outer and intermediate layers being bonded together to form a unitary, flexible structure.

17. The cup-type packer assembly of claim 13 wherein the packer is used for chemical stimulation at a zone in the wellbore casing and wherein, for each cup:

the inner elastomeric layer is fabricated from a chemically impervious elastomer; and

the outer layer is fabricated from an abrasion resistant elastomer.

18. The cup-type packer assembly of claim 16 further comprising:

one or more uphole cups mounted at an uphole end of the mandrel, each cup's annular body extending downhole from its base ring; and

one or more downhole cups mounted at a downhole end of the mandrel, each cup's annular body extending uphole from its base ring, the uphole and downhole cups' outer layers being resistant to abrasion during positioning of the packer in the wellbore casing and the uphole and downhole cups' inner layers being resistant to chemicals during higher pressure wellbore stimulation.

19. The packer cup as described in claim 16 wherein the inner layer is fabricated from Viton™.

20. The packer cup of claim 16 wherein the outer layer is fabricated from Nitrile™.

21. The packer cup as described in claim 16 wherein the inner layer is fabricated from Viton™ and the outer layer is fabricated from Nitrile™.

22. The packer cup as described in claim 16 wherein the reinforcing plies are metal cables.

23. The packer cup as described in claim 21 wherein the reinforcing plies are metal cables.

24. An improved packer cup constructed and arranged substantially as described in relation to Figs. 1 and 2 of the accompanying drawings

Application No: GB 0225807.7
Claims searched: 1 to 23

Examiner: Richard So
Date of search: 27 February 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
A	-	US 4424865 A	(PAYTON, Jr.). See whole document.
A	-	US 2723721 A	(CORSETTE). See whole document in particular 1, 2, and 8 to 12, and column 2 lines 24 to 40.
A	-	US 2305282 A	(TAYLOR et al.). See whole document in particular figures 1 and 2, page 1 lines 5 to 12.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

E1F.

Worldwide search of patent documents classified in the following areas of the IPC[7]:

E21B.

The following online and other databases have been used in the preparation of this search report:

EPODOC, JAPIO, WPI, TXTEP, TXTGB, TXTUS, TXTWO.